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ABSTRACT

One of the most common questions mathematics teachers hear from their students is a question of content value: "When am I ever going to use this?" This research paper looks at the question of content value for students enrolled in an elementary methods course designed to help them develop their abilities to teach mathematics At the end of each term, the professor asked students to identify the ten most important things they learned during the class. These qualitative data were collected across 7 years. Initially, each section of the course was analyzed as a single case. Researchers then looked at data across cases to identify common learnings. The areas identified as important by students were compared to the instructor's syllabi to determine how they aligned with learnings identified by the professor as important. Finally, the student-identified learnings were compared with those listed in national standards produced by the Association for Childhood Education International. Results of this study document the alignment (or lack thereof) between student, professor, and expert (standards) perspectives on the curriculum for preparation to teach elementary mathematics. Additionally, the paper documents how the data helped inform course revisions while the research was ongoing. (Author/SM)

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The "Formal," the "Planned," and the "Learned" Curriculum in an Elementary Education Methods Course for Mathematics: Three Perspectives on Course Content

Abstract: One of the most common questions mathematics teachers hear from their students is a question of content value: "When am I ever going to use this?" This research paper looks at the question of content value for students enrolled in an elementary education methods course designed to help them develop their abilities to teach mathematics. At the end of each term the professor asked students to identify the 10 most important things they learned during the class. These qualitative data were collected across seven years. Initially each section of the course was analyzed as a single case. Researchers then looked at data across cases to identify common learnings. The areas identified as important by students were compared to the instructor's syllabi to determine how they aligned with learnings identified by the professor as important. Finally, the student-identified learnings were compared with those listed in national standards produced by the Association for Childhood Education International (ACEI). Results of this study document the alignment (or lack thereof) between student, professor, and expert (standards) perspectives on the curriculum for preparation to teach elementary mathematics. Additionally, the paper documents how the data helped inform course revisions while the research was on-going.

Background

In July 1995 I transitioned from an elementary school classroom to a college classroom at Andrews University. Armed with enthusiasm, naivete, and a freshly minted PhD, I felt ready for anything. Since I was hired because of my background in science and mathematics, part of my initial teaching load was to cover the science and mathematics methods courses for elementary education students.

While I was more than ready to begin teaching the science methods course in the fall of 1995, I was a bit apprehensive about the math methods course scheduled for spring 1996. When I was hired I had been told "there are really good things happening in that class that we want to continue." The department chair wanted the course to change as little as possible when I took it over.

Making the course "mine"

As the math methods course was scheduled for both spring and summer terms in 1996, I decided to "teach someone else's course" for those two terms. By that I mean that I consulted with the former professor and changed very few things about her course. For some reason I decided that I would collect data from those first two times through the class and write a paper based on the experience for presentation. So I submitted a proposal for the Joint Conference on

Science and Mathematics to be held in Little Rock, Arkansas in the fall of 1996. The proposal was accepted and I began research about my math methods course.

The data from those first two sections of the course were useful in many ways. The data showed me what aspects of the course experiences were causing students concerns and stress. They also showed me what the students perceived as strong aspects of the course experience. The data provided a basis for making intelligent decisions about how to revise the course and make it mine.

Another major event in my professional life during the fall of 1996 was participation in my first accreditation site visit by the National Council for the Accreditation of Teacher Education (NCATE). As a result my experiences in spring and fall 1996, I set out to create "my own course." I wanted "my course" to be shaped by my classroom research (Burton, 1996) and be based on the official NCATE standards for elementary education programs, prepared by the Association for Childhood Education International (ACEI) (NCATE, 1989).

My questions

A foundational component of the math methods course I had inherited was the inclusion of a small action research project for all students. As I redesigned my math methods course I decided to retain that aspect of the course. I also decided to continue my own classroom research related to the course. As I began teaching "my class," In this second phase of my research, I wanted to know if my course revisions really made a difference. One way I attempted to answer this was through investigating the following questions.

1. What learning experiences, the 'learned' curriculum, did students value most in this revised course?

2. Did the 'learned' curriculum align with the "planned' curriculum, those learnings I valued as the professor?

3. Did the 'learned' curriculum align with the 'formal' curriculum (standards) articulated by experts?

My research process

To answer these questions I relied primarily on a final, reflective assessment activity I continued from the first two times I taught the class. For this reflective assignment, I asked students to list the ten most important things they learned in my class. I asked student to list these "important learnings" in order of importance. Additionally I required students to give short explanations of why each item on their list was important.

When explaining this assignment, I typically would be asked questions such as "Does it have to be things you (the prof) taught us?" I told the students they could list anything they learned. The only guideline I gave was that the learning had to be a direct result of involvement in the class experience.

I began analyzing the data as it was collected each term. As a result of this on-going analysis, I made small changes in the course content and activities. However, this paper represents the first complete reporting of the analysis of the data from eight sections of my re-designed class taught between 1997 and 2002.

To draw meaning from the students responses to my prompt, I used the inductive process of creating categories suggested by the data itself. Two doctoral students assisted me with the initial analysis of the data, which was conducted separately for each section of the course. We did this to determine if enough similarity existed in the data to allow for meaningful aggregation.

Categories were created by first looking at single items from the students' lists of top learnings and then looking for other items that mentioned similar things.

Once the single case analyses were completed, we compiled a table that listed all 30 categories we had created through this initial analysis. This table showed which classes had data that fit within those categories. Next we collapsed these 30 categories into 16 categories that seemed feasible for classifying the aggregated data. However, when we analyzed the aggregated data, we discovered the 16 categories were inadequate to fully represent the data. As a result, the actual number of categories in our aggregated analysis was 22. This was fewer categories than the original 30, but more than the 16 we had tried to use.

After the student responses were categorized, we began comparing the student responses with the planned curriculum, the professor's course plans, and the formal curriculum, national standards. First we accessed the standards document prepared for NCATE evaluation of elementary education programs by ACEI. This document was used for all NCATE site visits between Fall 1992 and Spring 2002. These standards, while not those in current use, do reflect those in effect during the most of the time span of this research. Rather than try to compare the students' responses to standards developed after most of the comments were made, we decided to compare all students' responses to the 1989 standards. Next we reviewed the course syllabi from Spring 1997, Summer 2000, and Summer 2002 to identify the course goals, materials, and assignments made by the professor. One purpose of this syllabi analysis was to determine what changes were implemented during the course of this study.

The Learned Curriculum

In looking at student perceptions of their most important learnings, 22 categories emerged. In alphabetical order they are as follows:

1. Action Research – General
2. Assessment
3. Changes in Mathematics Education
4. Classroom Climate
5. Concept Attainment
6. Cooperative Learning
7. Developing Conceptual Understandings
8. Field Experience
9. Fun & Games
10. Gender Equity
11. Instructional Methods – General
12. Interdisciplinary Teaching
13. Managing Behavior
14. Managing Instruction
15. Manipulatives
16. Mathematical Discourse
17. Personal Mathematics Understanding
18. Planning & Resources
19. Real Life Connections
20. Technology
21. Thinking Mathematically
22. Understanding Students

The Five Largest Categories. We can look at these categories both separately and in clusters of similar items. In looking at each separate category, five areas were mentioned by students more than the others (see Figure 1). The largest single category by far related to mathematical manipulatives, models, and representations. This category included 169 items reported by students.

Manipulatives. Students seemed to be fascinated with using manipulatives – often crediting the use of manipulatives with making math learning enjoyable and understandable. Said one student, "Working with fractions using manipulatives is actually fun. Actually, using manipulatives is fun. I gained a deeper appreciation and understanding of why to use manipulatives and how to do some operations with them. I'm sold – I will be using them in my classroom."

Within this category, many students described learning how to represent mathematical concepts in concrete or pictorial forms. Shandelle described this in personal terms. "Use of fraction circles really helped by in identifying fractions by using my hands and my brains. It also helped me to find more than one solution." Ronald described the importance of manipulatives in general terms, "Today just about any math can be taught in the classroom using some form of manipulatives. It is amazing to me how far we have come in making math tangible."

Some students listed important learnings about manipulatives related to student learning. Midge said, "It is important to use manipulatives . . . when teaching new material to young students who might not be able to grasp the concept in abstract forms." When explaining why learning to use manipulatives was so important, Samantha stated , "If students can experience a concept they are much more likely to use it again." Terri observed, "Multiplication has been a somewhat dreaded concept since most teachers use the drill and kill technique to have students memorize the facts. I think it is really important for students to develop an understanding of the concept of multiplication. The use of the base 10 blocks will be really important."

Toni said that one of the most important things she learned was "to use manipulatives and hands-on activities. While we were working with the students I noticed that the ones who were having difficulties were usually able to solve their problems when they were able to see what they were doing, using something other than just numbers."

Several students stated that they learned ways to manage students use of manipulatives in the classroom. Carissa stated it like this, "Working with manipulatives is tough at first if you've never worked with them. It's hard to know just how to use manipulatives. Practicing is good." Mike made this observation about learning to teach with manipulatives, "Always let students

play with manipulatives a few days before using them in a class. If students are familiar with them, they will not get distracted with the manipulatives and will focus on [learning]." Christelle learned that perseverance is necessary when teaching with manipulatives, "Students need time in order to become used to working with manipulatives. If at first you don't succeed with manipulatives, try, try, again."

Perhaps Jaime's observation represents this large category well, "**Manipulatives are our Friends!** Manipulatives are great because they let the children work out the problems with hands-on practice."

Planning & Resources. The second largest category, with 94 items, was Planning & Resources. This is not surprising as this is the first methods course most elementary education students take at Andrews University. Thus most of the pre-service teacher candidates in my class have had little experience with planning instruction. As a result, many are quite nervous about teaching students in a classroom for the first time. James put it simply, "Planning is everything." Juanita learned that "Planning for effective instruction is the beginning of effective instruction." Carl learned that it was important to "be prepared and organized. [I learned to] plan more activities than time allows because students may whip through activities that appear time consuming from a teacher's perspective."

Jia observed, "Planning ahead is important. I found that the lesson that I wasn't as prepared for, didn't go as well as the other two." Some students said it was important that they had learned to connect lesson planning to their students. Carlos learned it was important to "Plan your lessons with the students' minds being actively involved in the lesson. Reach the children's minds each time you teach."

Mona stated, "I have learned to make lesson plans as detailed as possible [so that they] can be easily followed by another teacher in case of emergencies." Roger observed that he needed to "be well prepared for [his] lessons. My better lessons have always been the ones I felt comfortable and prepared for. These last three weeks have reminded me of that."

Cooperative Learning. Cooperative learning was the third most-mentioned important learning (60 items). When I originally began teaching this course I 'encouraged' teacher candidates to use cooperative learning in their teaching. As a result of my first research of this class (Burton, 1996) I incorporated cooperative learning more fully into the course. This resulted in my requiring students to use cooperative learning in each of their original lesson plans. Within this category some students made comments about the general use of cooperative learning in mathematics education, their personal experience as a cooperative learner, and their personal use of cooperative learning in teaching.

"Cooperative Learning techniques have a place in math class," stated Charles. "Math is not all book work." Marlene said, "I never thought of using cooperative learning in math until this class, but it really does help [students] understand the concepts." Andrea learned about "the importance of teamwork. Math isn't always something that needs to be worked out alone. Group work allows for greater understanding."

Amanda stated "I learned that cooperative learning groups are very beneficial. While watching the students interact in their groups I was able to see students sharing what they knew and endeavoring to teach their group members. When I grouped students that understood with those who needed some coaching it was helpful for all involved. Cooperative learning groups is a must for the classroom." Senegugu noted, "Teamwork helps develop skills necessary for adult life."

Some students described learning to refine their use of cooperative learning. Concerning group formation, Xavier learned that "Heterogenous is best. A diverse group brings many strengths, skills, and strategies to a task, allowing all students to participate." Renita also learned that "heterogenous is best. A diverse group brings many strengths, skills, and strategies to a task allowing all students a chance to participate." Ronaldo observed, "Seating arrangements in groups should consist of girls and boys. I noticed that if a girl was among 3 boys in her group, they would try to gang up on her or exclude her ideas. An even number of girls and boys is the key."

Related to group functioning, Katie discovered that "Students like piggyback rides. As a teacher you have to be careful that all the students understand and that the students are doing their own work." Related to this idea of holding individuals responsible for their learning in cooperative groups, Marcel noted, "When using cooperative learning, individual accountability must be present. This prevents 'hitchhikers' and the problem of letting one person do all the work." Lawrence's observation focused on the idea of positive interdependence (Kagan, 1997) in cooperative learning. He learned that "Each team member needs the group to succeed. The group as a whole will be successful if each member is actively engaged in the learning process."

Mathematical Discourse. The fourth largest category (58 items) was Mathematical Discourse. This learning outcome was closely tied to the action research projects students conducted during this class. As part of their field experience, I sent students out in teams of three. While one person was teaching the class, another team member observed the teaching and collected data on mathematical discourse during the lesson. The observer recorded the types of questions asked by the teacher (high-level or low-level) and whether or not the questions were

addressed to males, females, or the whole class. Additionally, mathematical discourse was one of the primary criteria for evaluating each student's lesson plan.

Marilyn said simply, "It's important to facilitate mathematical discourse." In another succinct reply, Chris said he learned to "let students tell you the answer." Mai Yinch elaborated on the idea of having students 'tell the answer.' She learned to ask "students to justify responses. When I was teaching I made students tell me why they thought their problem was right and when they did this it reinforced the concept that was being presented."

Relevance was central to Ariel's learning. She learned to "ask the student meaningful questions. Don't ask the students questions that don't pertain to the lesson being taught. Be sure you understand their explanations." Nilda's response focused on "using more high-level questions: Giving my students the chance to really express their thoughts to solutions of problems." Marie's response indicated that assessment was one reason why she asked the students to explain their thinking. "I believe this is important because the student expresses what they understand and it helps the teacher know if learning is taking place."

Mitchell stated, "Teachers should have students talk and write about math. . . . talking and writing about math will help many students to understand and learn it better." Carla noted that "having students use and discuss problem solving strategies increases future performance."

Faith-Ann responded comprehensively, " Plan for student-centered lessons and mathematical discourse. Allow students to empower themselves to solve problems via their individualized abilities. The teacher should be actively listening as she/he guides and/or takes part in the activities with the students. High level questions may be asked of the children in order to spur on their thinking process, verbalize and even write down in words their solutions."

Some students learned skills for facilitating discourse. Agnes learned that "a teacher should not be too quick to answer student questions. What I mean by this is not necessarily [to] not answer the question the student has, but instead the key is to delay giving him/her the answer at the first call for 'help.' I believe that our first response should be to have that student question her/himself. If the student's inclination is to initially inquire of the teacher, the teacher in turn should put the question right back at them. Leading the students to think for themselves, I believe, should be the educator's main objective."

Field Experience. The fifth most mentioned category was Field Experience. While many were initially frightened by the field experience portion of this class, every students' learning was influenced by it. Melanie phrased it this way, "I liked that for a great portion of our time in this class, we were actually TEACHING the kids in the classroom. Nothing beats the actual experience."

"Classes can never prepare someone for actually teaching in the classroom," said Marcus. "Nothing can prepare a person for what actually lies ahead in the classroom. You can help them know experiences that might help or techniques, but as to what will actually happen, there is no lesson that can teach you what to do or how to be ready."

Cyndi, who had stated she only wanted to teach in K-3, responded in this way at the end of her field experience with students in the middle elementary grades. "I can teach comfortably and effectively beyond my comfort zone of the primary grades. When you push yourself beyond your preconceived ability, you have truly experienced 'real' learning."

Some students reflected on how the structure of the field experience helped them be successful. Some of these comments were about the supervising teacher, some about the university professor, and some about the three-person teaching team. In 1997 Carmel learned to

"work with the supervising teacher. Our teacher knew a lot of information that could have helped us if we had talked to her at the beginning." As a result of observations such as this, I began requiring my students to observe their cooperating teachers classroom and discuss their teaching plans with her before the teaching portion of the field experience began. After this adjustment, Melissa commented, "Our teacher's observation was quiet and non-disruptive; but very helpful and constructive." Kelly was appreciative that she was able "to receive knowledgeable tips from experienced teachers. Listening to the advice of the skilled teacher in the classroom we worked in helped us improve our lessons and interaction with the students."

Lucette described the length of time spent in the classrooms by the university professor. She replied, "Being watched. I'm glad that you didn't stay very long when you visited our little teaching sessions. It would have made me more nervous." Daphne's observation complements Lucette's perspective. Daphne said, "No Abandonment. You did not abandon us at [the elementary school]. It would have been sad if you had just dropped us off and never checked up on us. I liked the fact that you would visit different classrooms and answer any questions that we might have asked you right on the spot. Very Cool!!!"

Roxie stated "Team teaching is wonderful. I was a little bit nervous about going into a 5th grade classroom by myself (because I'm used to the younger ones). But I found that because I had my little 'support' group with me, it was much easier to feel confident in my presentation. It was like we were all in it together." In a similar comment, Kevin learned that "Everyone teaches differently. Watching my group members teach reminded me that everyone has a unique way of interacting with students."

Another Perspective. We can get a slightly different perspective by looking at the top 3 items listed by each student and ignoring the items lower on their lists. That can give us an idea

of what that student viewed as *really* important. When we do that with this data, there are interesting variations in the five largest categories (see Figure 2). Manipulatives, with 60 items, is still the largest category with more than twice as many items than any other group. Mathematical Discourse, Planning & Resources, and Field Experience remain as members of the five largest categories though in a different order.

When looking at students' top three items only, the Fun & Games category moved up to the 5th position from a 10th place rating when all student responses were included in the analysis. The Fun & Games category included statements that expressed students' surprise that learning mathematics could be an enjoyable experience.

Fun & Games. "Math can be fun to learn as well as teach. I was very concerned because I really didn't like math very much at all," said Monique. Geoffery learned "that it is possible to make learning math fun for kids. I included this because if we don't make learning math fun then kids will not enjoy learning math." Roger noted that he had learned how to make mathematics more enjoyable for children. "Math can be extremely fun and students will enjoy it if you can reach them through various techniques (manipulatives, real life experience, etc...)."

Therese said, "Math CAN be FUN: I learned not to let my anxieties get in the way of actually enjoying learning and teaching math." Esther's personal experience affected her vision for her elementary classroom: "Math is fun. OK, it can be. I had fun in class using the fun new manipulatives and it made me wish that every student could enjoy math rather than dread it." Raeann had a similar response, "Math can be fun to learn as well as teach. I was very concerned [when I began this class] because I really didn't like math very much at all."

Some students mentioned specific instructional games that had been introduced as a part of the class. Roberta valued "Toss-a-Rectangle – [a] fun way to multiply and divide." Doug wrote, "Why ***Coverup***? This game gets students practicing decimals, fractions, and percents."

Heidi made observations about learning to refine her use of 'fun' activities in teaching mathematics. "Sometimes too much fun activity, especially at the beginning of a lesson, takes the students' focus off the lesson and makes it harder for them to get into math or other lessons. You start doing a bunch of fun stuff, and then you have to suddenly switch tracks. Unless done properly, the lesson can be led into a wrong focus, or create too [many]distractions . . . Use moderation, or a well-organized, planned-out [transition between activities]."

Alignment with the Planned and the Formal Curriculum

To address the alignment, or lack thereof, between the learned, the planned, and the formal curriculum, I looked at each student-generated category and first tried to link them to ACEI standards and course goals, as the course goals are paraphrases of the ACEI standards. Two of the student-generated categories of important learnings link to a single ACEI standard. The other 20 categories link to multiple standards (see Table 1). This level of linkage seems to indicate that the categories students identified as important for their learning are closely aligned with national standards and the goals of the course. (See Appendix A for a short listing of the ACEI standards.)

After looking for alignment with the standards, I attempted to connect each student-generated category to specific course assignments. In my analysis, each student-generated category can be linked directly to at least two course assignments, while most link to multiple assignments (see Table 1). This level of linkage seems to indicate that the student-generated categories of important learnings are closely aligned with the implementation of the course as

defined by the major assignments and activities planned by the professor. (A synthesis of data from the course syllabus is found in Appendix B.)

Another way of looking at the degree of alignment between the "learned" and the "planned" curriculum is to consider the relative sizes of the student-generated categories and the weight given by the professor to the linked course assignments. I completed a comparison of this

Table 1. Alignment of Perspectives on Course Content

Student-generated Category	Course Assignments	ACEI Standards/ Professor's Goals
Action Research – General	Action Research Readings Teaching Elementary Students	1.0, 2.0, 3.0, 7.0
Assessment	Readings Teaching Elementary Students Writing to Learn	3.0
Changes in Mathematics Education	Conceptual Quizzes Exams Readings Writing to Learn	1.0, 2.0, 5.0
Classroom Climate	Participation Readings	3.0, 4.0, 6.0
Concept Attainment	Lesson Plans Participation Readings Teaching Elementary Students	3.0, 4.0, 5.0
Cooperative Learning	Participation Readings Teaching Elementary Students	3.0, 4.0, 5.0
Developing Conceptual Understandings	Readings Writing to Learn	2.0, 3.0, 4.0, 5.0, 6.0
Field Experience	Action Research Teaching Elementary Students Teaching Strategies Grid	1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0
Fun & Games	Participation Readings	2.0, 3.0, 4.0, 5.0
Gender Equity	Action Research Readings	1.0, 3.0, 4.0, 6.0, 12.1
Instructional Methods – General	Participation Teaching Elementary Students	4.0, 5.0
Interdisciplinary Teaching	Participation Readings	2.0, 4.0, 5.0, 13.0
Managing Behavior	Readings Teaching Elementary Students	1.0, 3.0, 4.0, 8.0
Managing Instruction	Readings Teaching Elementary Students	1.0, 4.0, 8.0, 9.0

Table 1. Alignment of Perspectives on Course Content, continued

Student-generated Category	Course Assignments	ACEI Standards/ Professor's Goals
Manipulatives	Conceptual Quizzes Course Materials Exams Participation Readings Teaching Elementary Students Teaching Strategies Grid	2.0, 3.0, 4.0, 5.0, 6.0, 12.4, 12.5, 12.6, 12.7, 12.9
Mathematical Discourse	Participation Readings Writing to Learn Teaching Elementary Students	2.0, 3.0, 4.0, 5.0, 6.0, 12.1, 13.0
Personal Mathematics Understanding	Conceptual Quizzes Exams Participation Readings Writing to Learn	12.0
Planning & Resources	Concept Attainment Lessons Readings Teaching Elementary Students Teaching Strategies Grid	1.0, 3.0, 4.0, 9.0
Real Life Connections	Lesson Plans Teaching Strategies Grid	2.0, 3.0, 4.0, 5.0, 6.0, 12.2
Technology	Readings Technology Competencies	2.0, 4.0, 9.0, 12.8
Thinking Mathematically	Participation Readings	2.0, 3.0, 4.0, 5.0, 6.0, 12.3
Understanding Students	Readings Teaching Elementary Students	3.0, 4.0, 6.0, 9.0

type for the top 5 student-created categories of important learnings (see Table 2). When looking at the data from this perspective, we notice that the assignments that contributed to these categories of learnings accounted for at least 40% of the students total grade. Some of these assignment clusters accounted for as much as 75% of the student's total grade in 1997. It thus appears that the learnings identified as important by the students were also valued in the planned curriculum as indicated by their impact on the final grade.

Table 2. Relative Weights of Categories and Related Course Assignments

Student-generated Category	% of Total Responses	Course Assignments	% of Total Grade
Manipulatives	16.5%	Conceptual Quizzes (0-5%) Exams (4-20%) Participation (4-10%) Readings (0-15%) Teaching Elementary Students (24-40%) Teaching Strategies Grid (5-8%)	75% ('97) 65% ('00) 60% ('02)
Planning & Resources	9.2%	Concept Attainment Lessons (0-8%) Readings (0-15%) Teaching Elementary Students (24-40%) Teaching Strategies Grid (5-8%)	45% ('97) 40% ('00) 55% ('02)
Cooperative Learning	5.8%	Participation (4-10%) Readings (0-15%) Teaching Elementary Students (24-40%)	50% ('97) 40% ('00) 43% ('02)
Mathematical Discourse	5.7%	Action Research (8-20%) Participation (4-10%) Readings (0-15%) Writing to Learn (0-7%) Teaching Elementary Students (24-40%)	70% ('97) 65% ('00) 58% ('02)
Field Experience	5.2%	Action Research (8-20%) Teaching Elementary Students (24-40%) Teaching Strategies Grid (5-8%)	65% ('97) 55% ('00) 40% ('02)

Another way of looking at the alignment of the learned and the planned curricula is to look at the single largest point-value assignment in this class, Teaching Elementary Students. This assignment never accounted for less than 24% of the total course grade and sometimes counted as much as 40% of the grade. Twelve of the 22 student-generated categories are linked to this assignment (see Table 1). This seems to indicate the efficacy of this assignment from the planned curriculum to produce significant learnings within the students taking this course.

Discussion

Why "Manipulatives?" The data from this study documents the students overwhelmingly positive response to the use of manipulatives and models for learning and teaching mathematical concepts. Based on the data and informal discussion with students in the classes over the years, one possible reason for this reaction is the student's prior mathematics learning experiences. Most students in my mathematics methods course have had at least one negative experience in mathematics. Many have had consistently negative experiences from middle school on. Only a handful have ever been exposed to learning mathematics through manipulatives or teaching mathematics with them.

I still remember one class period when I asked students, "Why we read 5^2 as 'five squared'?" I followed that by asking, "Why do we read 4^3 as 'four cubed'?" I then had students use multilink cubes to model square numbers as arrays and cubed numbers multilevel arrays. The students finished their models and were amazed when the model for a square number formed the shape of a square. Similarly the the model for a cubed number formed the shape of a cube. An honors student said excitedly, "OK, I finally get it." Before that discovery, she had never understood the language for reading exponents to the power of 2 or 3 was connected to the shapes they modeled. What had been a meaningless vocabulary term and a "rule" to remember

suddenly became a readily accessible component of her conceptual understanding of mathematics.

For me, the explanation of why the Manipulative category is so large for these students lies in the following two points. First, these students have not been taught with manipulatives. Therefore they are amazed at how well manipulatives can help build conceptual understanding and model mathematics. Secondly, since they have not been taught with manipulatives, they have many things to learn about teaching with manipulatives. They had only seen one model – the math methods professor. So it seems that the students' enthusiasm for a powerful learning tool combined with the need to learn how to use it both effectively and efficiently contributes to the students perceptions of the use of Manipulatives as the single most important learning from this class.

What next?

I can think of several possibilities for further analysis of this data and related research to conduct. A complete discussion of each of the large categories in this study should be written to better document the varied voices of the students in this class. The brief description of six categories in this paper is inadequate to fully document what students communicated about their learning. Similarly, similarities between some categories may enable clustering of categories for further analysis and interpretation. This clustering could provide important perspectives on questions such as, "What experiences contribute to a positive field experience?"

Suggestions for additional research include conducting a follow-up study with beginning teachers to ask them to reflect back on their mathematics methods training and tell us, from the perspective of three years out, what was of value from that course. We could also extend the conversation to practicing teachers in need of professional development in mathematics. What

do practicing teacher perceive as their professional development needs in mathematics education? How are those similar to or different from the needs of pre-service teachers?

References

Burton, L. D. (1996). *Focusing on Equity in an Elementary Mathematics Methods Course.* Paper presented at the Joint Conference on Teaching Science and Mathematics. (ERIC Document Reproduction Service ED 402 185)

Kagan, S. (1997). *Cooperative Learning.* San Juan Capistrano, CA: Kagan Cooperative Learning.

Appendix A

Association for Childhood Education International (ACEI) Standards

© 1989, NCATE

Used for NCATE reviews from Fall 1992 through Fall 2000

Note: Standards 10.0, 11.0, 14.0, 15.0, and 16.0 are not included as they do not pertain to mathematics teaching in the elementary school.

1.0 Programs should provide teacher candidates with an understanding of the roles of elementary school teachers and the alternative patterns of elementary school organization.

2.0 Programs should provide study and experience concerning the role of the teaching profession in the dynamics of curriculum change and school improvement.

3.0 Programs should include study and experiences, throughout the professional studies sequence, that link child development to elementary school curriculum and instruction.

4.0 Programs should develop the teacher candidates' capacities to organize and implement instruction for students.

5.0 Programs should include study and application of a variety of developmentally appropriate experiences that demonstrate varied approaches to knowledge construction and application in all disciplines.

6.0 Programs should include study and application of current research findings about individual differences.

7.0 Programs should provide a well-planned sequence of varied clinical/field experiences with students of different ages, cultural and linguistic backgrounds, and exceptionalities. These experiences should connect course content with elementary school practice.

8.0 Programs include opportunities to study, analyze, and practice effective models of classroom management in campus and field-based settings, and to engage in a gradual increase in responsibility.

9.0 Programs should provide study and experiences for critically selecting and using materials, resources, and technology appropriate to the age, development level, cultural and linguistic backgrounds, and exceptionalities of students.

12.0 Programs should prepare teacher candidates to become confident in their ability to do **mathematics** and to create an environment in which students become confident learners and doers of mathematics. Programs include study of and experiences with:

- 12.1 The development of student's abilities to communicate mathematically through reading, writing, listening and discussing ideas.
- 12.2 The cultural, historical and scientific applications of mathematics so that students can learn to value mathematics.
- 12.3 The structuring of classroom activities around making conjectures, gathering evidence and building arguments so that students learn to reason mathematically.

12.4 The construction of the meaning of numeration and the development of number sense.

12.5 The construction and exploration of models of estimation strategies for numbers, operations and measurement.

12.6 The development of activities to explore the geometry of one, two and three dimensions so that students can visualize and represent geometric figures and understand and apply spatial relationships.

12.7 The process of developing measurement and related concepts.

12.8 The use of various kinds of calculators and other technologies as teaching tools for computation, problem solving, and explorations.

12.9 The use of concrete manipulative materials in the classroom.

13.0 Programs in the area of students' literacy development should be designed to help teacher candidates create experiences for their students in **reading, writing and oral language**. These programs should stress the integration of reading, writing and oral language with each other and with the content areas of the elementary school curriculum.

Appendix B

Evidence from the Course Syllabus

Course Materials

- Textbook
- *Starting with Manipulatives* kit from ETA/Cuisenaire, including a resource binder
- Required to prepare 2 sets of die cut manipulatives

Course Goals

Teacher candidates will:

1.0 develop an understanding of the role of an elementary mathematics teacher and organization patterns for elementary schools.

2.0 study and experience the role of the teaching profession in curriculum change and school improvement.

3.0 investigate the links between child development, elementary school curriculum, and instructional practices.

4.0 develop the capacity to organize and implement instruction for students.

5.0 study and apply developmentally appropriate experiences to facilitate the construction of mathematical knowledge.

6.0 study and apply current research about individual differences.

7.0 participate in well-planned field experiences with students of different ages, cultural and linguistic backgrounds, and exceptionalities.

8.0 study, analyze, and practice effective models of classroom management in field-based settings.

9.0 critically select and use materials, resources, and technology appropriate to the age, developmental level, cultural and linguistic differences, and exceptionalities of students.

12.0 become confident in their ability to do mathematics and create an environment in which students become confident learners and doers of mathematics.

13.0 create experiences that stress the integration of reading, writing, and oral language with mathematics.

Course Assignments

(Showing Typical Percentage of Total Grade)

1.	Teaching Elementary Students	24-40%
2.	Concept Attainment Lessons (added in Spring 2002)	0-8%
3.	Technology Competencies	5-16%
4.	Teaching Strategies Grid	5-8%
5.	Action Research	8-20%
6.	Conceptual Quizzes	0-5%
7.	Required Readings	0-15%
8.	Writing to Learn	0-7%
9.	Exams	4-20%
10.	Attendance & Participation	4-10%
11.	Research Reading Reports (Graduate Students Only)	0-6%

Figure 1: Most Important Learnings

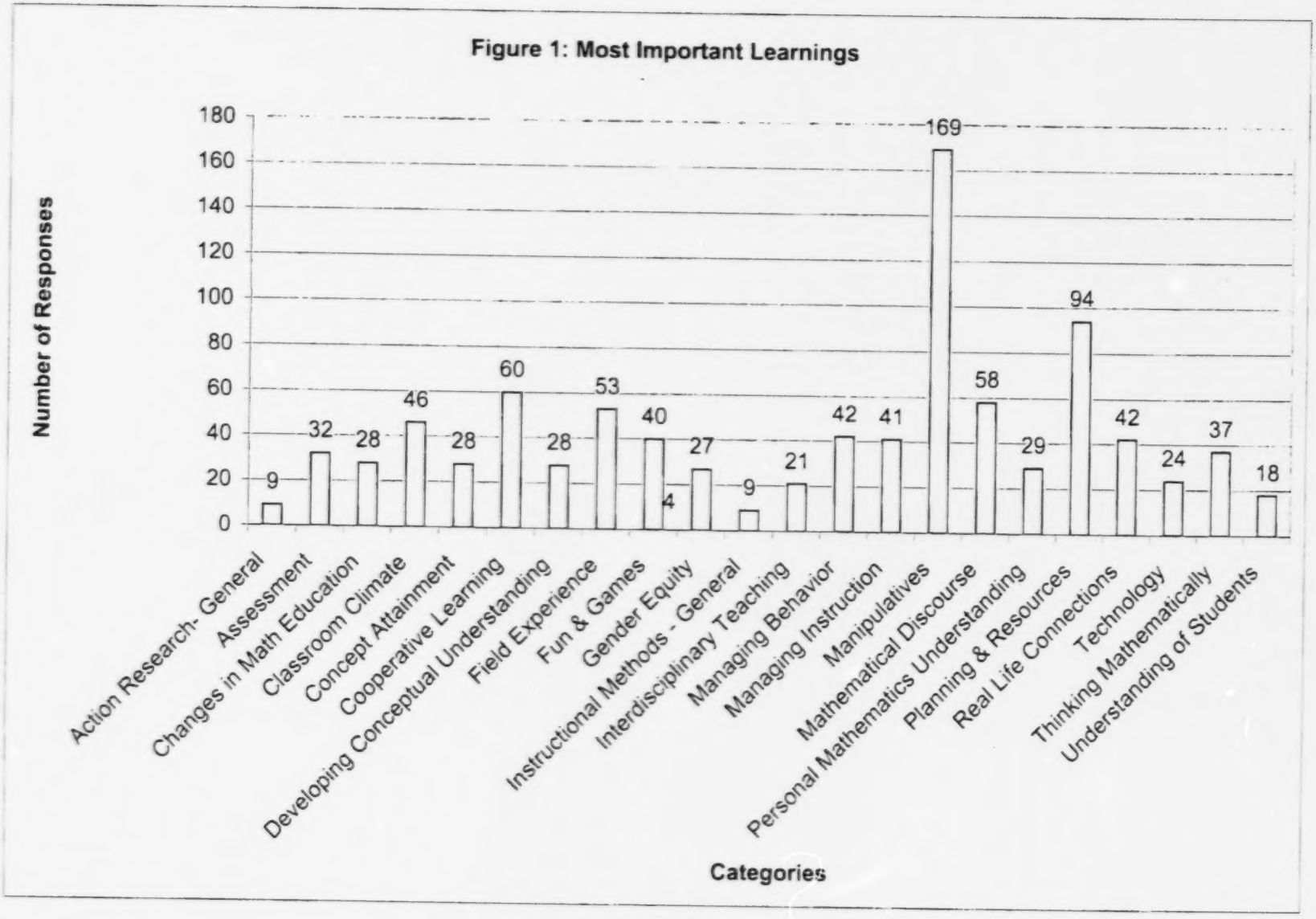
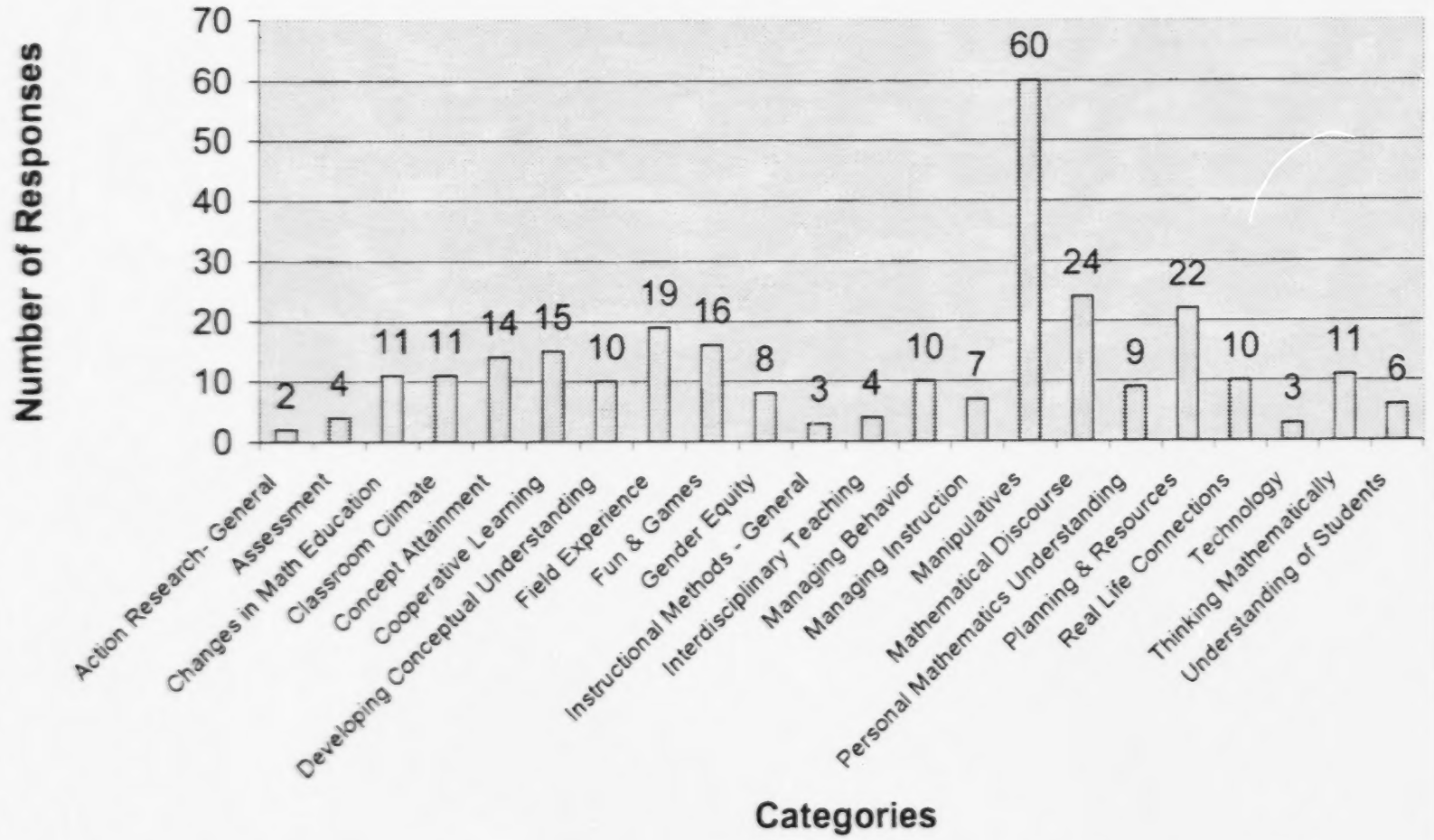


Figure 2: Responses Rated 1st, 2nd, or 3rd



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